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Indian Standard

SPECIFICATION FOR MACHINING ALLOWANCES AND TOLERANCES FOR OPEN DIE STEEL FORGINGS

PART 1 CARBON AND LOW ALLOY STEEL FORGINGS

UDC 669·14-134+669·15-194·2-134:621·73·042/·043:621·753·1

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Indian Standard

SPECIFICATION FOR MACHINING ALLOWANCES AND TOLERANCES FOR OPEN DIE STEEL FORGINGS

PART 1 CARBON AND LOW ALLOY STEEL FORGINGS

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Indian Standard

SPECIFICATION FOR MACHINING ALLOWANCES AND TOLERANCES FOR OPEN DIE STEEL FORGINGS

PART 1 CARBON AND LOW ALLOY STEEL FORGINGS

0. FOREWORD

0.1 This Indian Standard (Part 1) was adopted by the Indian Standards Institution on 18 May 1983, after the draft finalized by the Steel Forgings Sectional Committee had been approved by the Structural and Metals Division Council.

0.2 The tolerances for open die steel forgings were earlier covered in IS : 3469-1966*. However, when the standard was revised it was agreed to prepare separate standards covering tolerances for open and closed die steel forgings. Accordingly the following standards covering the tolerances for closed die steel forgings have already been published:

> IS : 3469 (Parts 1 to 3) - 1974 Tolerances for closed die steel forgings (*first revision*).

0.3 This standard (Part 1) deals with tolerances for open die steel forgings. Part 2 of this standard covers forgings made from high alloy steels.

0.4 Additional allowances due to warpage and twist (circular and rectangular) have not been covered for the present and if required may be agreed to between the purchaser and the supplier.

0.5 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS : 2-1960†. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This standard (Part 1) covers the machining allowances and tolerances for open die steel forgings made from carbon and low alloy steels.

2. MACHINING ALLOWANCES AND TOLERANCES

2.1 These shall be as given in Tables 1 to 7.

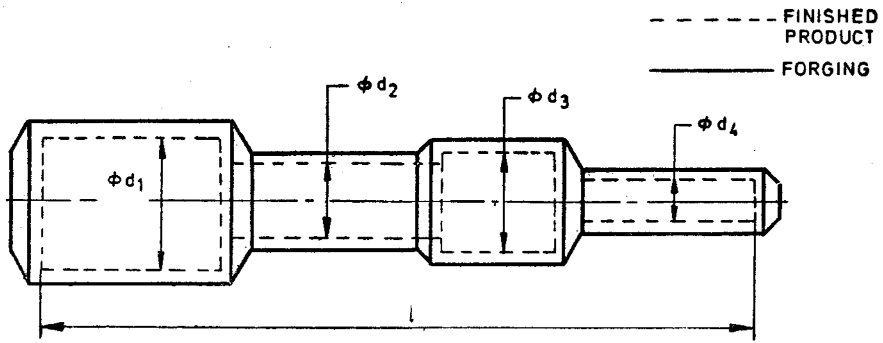
---

*Tolerances for steel drop forgings, upset forgings, press forgings and forged bars.

†Rules for rounding off numerical values (*revised*).

TABLE 1 MACHINING ALLOWANCES AND FORGING TOLERANCES ON CROSS SECTIONS FOR FREE-FORGED PLAIN OR STEPPED SHAFTS

All dimensions in millimetres.



LENGTH OF THE FINISHED PRODUCT, *l*		DIAMETER *d* OF THE FINISHED PRODUCT															
		OVER→	–	30	50	80	120	180	250	315	400	500	630	800	1 000	1 250	1 600
FROM	TO	UP TO→	30	50	80	120	180	250	315	400	500	630	800	1 000	1 250	1 600	2 000
			ALLOWANCES ON SECTION														
	250		7 ± 2	7 ± 2	9 ± 3	12 ± 4	15^{+5}_{-3}	17^{+7}_{-5}	–	–	–	–	–	–	–	–	–
251	400		9 ± 2	8 ± 2	10 ± 3	13 ± 4	16^{+5}_{-3}	20^{+7}_{-5}	21^{+9}_{-6}	–	–	–	–	–	–	–	–
401	630		9 ± 2	10 ± 2	12 ± 3	14 ± 4	17^{+5}_{-3}	20^{+7}_{-5}	22^{+9}_{-6}	28^{+12}_{-8}	31^{+15}_{-10}	35^{+19}_{-12}	–	–	–	–	–
631	1 000		10 ± 2	12 ± 2	14 ± 3	16 ± 4	19^{+5}_{-3}	21^{+7}_{-5}	24^{+9}_{-6}	29^{+12}_{-8}	32^{+15}_{-10}	36^{+19}_{-12}	40^{+24}_{-16}	46^{+30}_{-20}	55^{+37}_{-25}	–	–
1 001	1 600		12 ± 2	13 ± 2	14 ± 3	16 ± 5	20^{+5}_{-3}	22^{+7}_{-61}	24^{+9}_{-6}	30^{+12}_{-8}	32^{+15}_{-10}	37^{+19}_{-12}	42^{+24}_{-16}	45^{+30}_{-20}	57^{+37}_{-25}	65^{+45}_{-30}	–

1 601	2 500	14±2	15±3	16±4	18±5	23^{+6}_{-4}	26^{+8}_{-6}	28^{+10}_{-7}	30^{+14}_{-9}	33^{+18}_{-11}	39^{+22}_{-13}	43^{+28}_{-17}	48^{+35}_{-20}	60^{+43}_{-25}	72^{+52}_{-30}	85^{+62}_{-35}
2 501	3 150	14±3	16±3	17±4	19±6	24^{+6}_{-4}	27^{+8}_{-6}	29^{+10}_{-7}	31^{+14}_{-9}	35^{+18}_{-11}	41^{+22}_{-13}	44^{+28}_{-17}	50^{+35}_{-20}	62^{+44}_{-25}	76^{+54}_{-30}	90^{+65}_{-35}
3 151	4 000	15±3	17±3	18±4	20±6	24^{+6}_{-4}	28^{+10}_{-6}	30^{+10}_{-7}	32^{+14}_{-9}	37^{+18}_{-11}	43^{+22}_{-13}	46^{+28}_{-17}	52^{+35}_{-20}	62^{+44}_{-25}	76^{+54}_{-30}	90^{+65}_{-35}
4 001	5 000	–	–	19±5	21±6	25^{+6}_{-4}	28^{+10}_{-6}	30^{+12}_{-7}	33^{+16}_{-9}	37^{+20}_{-11}	45^{+25}_{-13}	50^{+30}_{-17}	55^{+40}_{-20}	65^{+50}_{-25}	78^{+61}_{-32}	–
5 001	6 300	–	–	–	22±8	26^{+6}_{-5}	29^{+10}_{-7}	31^{+12}_{-8}	34^{+16}_{-10}	39^{+20}_{-12}	48^{+25}_{-14}	52^{+32}_{-21}	58^{+40}_{-21}	67^{+50}_{-26}	82^{+61}_{-32}	–
6 301	8 000	–	–	–	–	26^{+7}_{-5}	29^{+11}_{-7}	32^{+12}_{-8}	35^{+16}_{-10}	42^{+20}_{-12}	50^{+25}_{-14}	54^{+32}_{-18}	60^{+40}_{-21}	70^{+50}_{-26}	85^{+61}_{-32}	–
8 001	10 000	–	–	–	–	26^{+7}_{-5}	30^{+11}_{-7}	33^{+14}_{-8}	36^{+18}_{-10}	45^{+23}_{-12}	53^{+28}_{-14}	57^{+36}_{-18}	62^{+45}_{-21}	75^{+55}_{-26}	–	–
10 001	12 500	–	–	–	–	–	41^{+11}_{-7}	45^{+14}_{-8}	49^{+18}_{-10}	54^{+23}_{-12}	58^{+28}_{-14}	62^{+36}_{-18}	66^{+45}_{-21}	–	–	–
12 501	16 000	–	–	–	–	–	48^{+11}_{-7}	52^{+14}_{-8}	56^{+14}_{-10}	60^{+23}_{-12}	67^{+28}_{-14}	71^{+36}_{-18}	75^{+45}_{-21}	–	–	–

NOTE – Machining allowances and forging tolerances are:

a) applicable to both circular and rectangular shafts, and
b) upper limit of tolerance will be 40 percent more for stepped shafts.

TABLE 2 MACHINING ALLOWANCES AND FORGING TOLERANCES ON LENGTH FOR FREE-FORGED PLAIN OR STEPPED SHAFTS (PRESS FORGINGS)

All dimensions in millimetres.

Diameter '*d*' of the Finished Product	Length '*l*' of the Finished Product, mm									
Over →	—	500	1 000	1 600	2 500	3 750	5 400	7 500	10 000	13 000
Up to →	500	1 000	1 600	2 500	3 750	5 400	7 500	10 000	13 000	16 000
	Allowances on Length									
Up to 500	30^{+15}_{-10}	35^{+20}_{-10}	40^{+25}_{-15}	45^{+30}_{-20}	50^{+35}_{-25}	60^{+40}_{-30}	70^{+45}_{-35}	80^{+50}_{-40}	90^{+55}_{-45}	100^{+60}_{-50}
501 to 1 000	35^{+20}_{-10}	40^{5}_{-15}	45^{+30}_{-20}	50^{+35}_{-25}	60^{+40}_{-30}	70^{+45}_{-35}	80^{+50}_{-40}	90^{+55}_{-40}	100^{+60}_{-50}	110^{+65}_{-55}
Above 1 000	40^{+25}_{-15}	45^{+30}_{-20}	50^{+35}_{-25}	60^{+40}_{-30}	70^{+45}_{-35}	80^{+50}_{-40}	90^{+55}_{-45}	100^{+60}_{-50}	110^{+65}_{-55}	120^{+70}_{-60}

NOTE — Machining allowances and forging tolerance are:

a) applicable for both circular and rectangular shafts, and

b) upper limit of tolerance will be 40 percent more for stepped sections.

TABLE 3 MACHINING ALLOWANCES AND FORGING TOLERANCES ON LENGTH FOR FREE-FORGED PLAIN OR STEPPED SHAFTS (HAMMER FORGINGS)

All dimensions in millimetres.

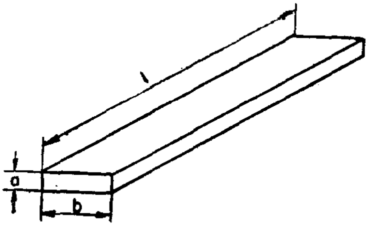
DIAMETER '*d*' OF THE FINISHED PRODUCT	LENGTH '*l*' OF FINISHED PRODUCT, mm				
OVER→	–	500	1 000	1 600	2 500
UP TO→	500	1 000	1 600	2 500	3 750
	ALLOWANCES ON LENGTH				
Up to 100	20^{+8}_{-4}	25^{+10}_{-5}	30^{+15}_{-8}	35^{+20}_{-10}	40^{+25}_{-15}
101 to 250	30^{+15}_{-8}	35^{+20}_{-10}	40^{+25}_{-15}	45^{+30}_{-20}	50^{+35}_{-25}

NOTE — Machining allowances and forging tolerances are:

a) applicable for both circular and rectangular shafts, and

b) upper limit of tolerance will be 40 percent more for stepped sections.

TABLE 4 FORGING ALLOWANCE AND TOLERANCE ON FLAT SECTIONS



a, *b* and *l* are machined sizes

$\frac{a}{b}$	FORGING ALLOWANCE AND TOLERANCE ON *a* AND *b*
⩽ 1 : 7	Normal working allowance and tolerance according to Tables 1, 2 and 3 for size *a* and *b*
⩽ 1 : 8	For size *a*, increase allowance and tolerance by 15 percent
⩽ 1 : 9	For size *a*, increase allowance and tolerance by 30 percent
⩽ 1 : 10	For size *a*, increase allowance and tolerance by 75 percent
> 1 : 10	To be decided by the technologist on individual basis

NOTE — Forging allowance and tolerance on *a* and *b* will be determined separately according to *a* and *l* and *b* and *l* respectively.

2.2 Additional forging allowance due to eccentricity in stepped shafts including rolls shall be calculated as given in Fig. 1. The value so calculated shall be added to the diameter when $l > 8d_1$ and d_1/d_2 or $d_1/d_3 > 1{\cdot}6$.

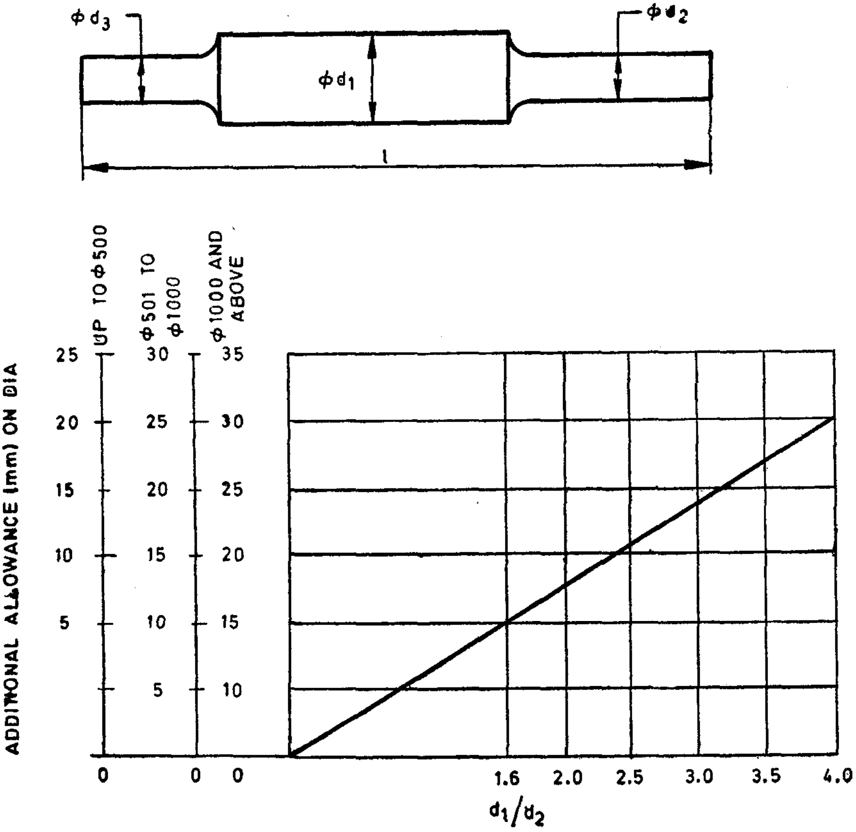


FIG. 1 METHOD OF CALCULATING ADDITIONAL FORGING ALLOWANCE DUE TO ECCENTRICITY IN STEPPED SHAFTS INCLUDING ROLLS

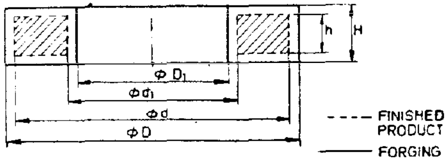
3. TECHNOLOGICAL INSTRUCTION FOR FORGING STEPPED FLANGED AND NECKED SHAFTS

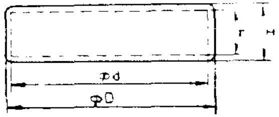
3.1 In case of stepped shafts (round or square) where ratio between two adjacent dimensions of any step, for example, d_1/d_2 or d_1/d_3 or d_2/d_3 (Fig. 2) $\leqslant 1{\cdot}6$, allowance and tolerance for d_1, d_2 and d_3, l_1, l_2 and l_3 and l will be on the basis of d_1 and l as per Tables 1, 2 and 3.

TABLE 5 MACHINING ALLOWANCE AND FORGING TOLERANCES FOR FREE-FORGED

1. SOLID BLANKS, 2. HOLLOW BLANKS

(where $h \leqslant d$, $d_1 \leqslant 1/3\ d$)





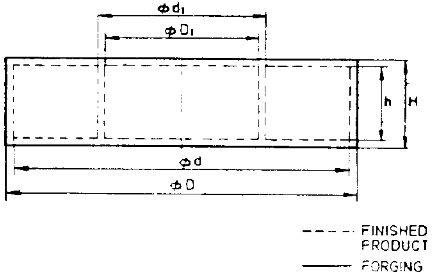
All dimensions in millimetres.

Outside Diameter ‘*d*’ of the Finished Product		Height ‘*h*’ of the Finished Product																							
	Over →	—		40		63		100		160		200		250		315		400		500		630		800	
	Up to and Including →	40		63		100		160		200		250		315		400		500		630		800		1 010	
		Allowance on																							
From	To	*d*	*h*	*d*	*h*	*d*	*h*	*d*	*h*	*d*	*h*	*d*	*h*	*d*	*h*	*d*	*h*	*d*	*h*	*d*	*h*	*d*	*h*	*d*	*h*
63	100	8±2	7±2	8±2	7±2	9±2	8±2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
101	160	8±3	7±2	9±3	8±2	9±3	8±2	10±3	9±3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
161	200	9±3	8±3	9±3	8±3	11±4	9±3	13±4	12±3	15±4	13±4	—	—	—	—	—	—	—	—	—	—	—	—	—	—
201	250	10±4	9±3	12±4	9±3	14±4	10±4	16±5	14±4	18±5	16±4	20±5	18±5	—	—	—	—	—	—	—	—	—	—	—	—
251	315	12±6	10±4	14±6	10±4	17±6	12±4	20±7	15±5	22±7	18±6	22±7	20±6	24±8	22±7	—	—	—	—	—	—	—	—	—	—
316	400	—	—	16±6	12±4	19±7	13±5	22±8	16±6	24±8	18±6	25±9	20±7	26±10	22±8	27±11	25±9	—	—	—	—	—	—	—	—
401	500	—	—	—	—	22±8	14±6	25±9	18±7	28±10	22±7	29±11	24±8	30±12	25±9	32±12	30±10	35±13	32±11	—	—	—	—	—	—
501	630	—	—	—	—	25±9	17±7	30±10	22±8	32±11	26±8	34±12	30±9	36±13	32±10	37±13	33±10	35±14	34±11	40±15	35±12	—	—	—	—
631	800	—	—	—	—	29±10	21±8	34±11	27±9	36±12	30±9	38±13	33±10	40±14	34±11	42±15	35±11	43±16	37±12	44±17	38±13	45±18	39±14	—	—
801	1000	—	—	—	—	34±12	28±9	38±12	33±10	40±13	35±10	42±14	38±11	44±15	38±12	46±16	39±12	48±17	41±13	51±18	41±14	52±19	41±15	53±20	41±16
1 001	1 250	—	—	—	—	40±13	35±10	43±13	38±11	45±14	39±11	47±15	41±12	49±16	41±13	51±17	43±13	53±18	44±14	55±19	44±15	57±20	44±16	58±21	45±17
1 251	1 600	—	—	—	—	—	—	49±14	42±12	52±15	44±12	53±16	44±13	54±17	45±14	56±18	46±14	58±19	46±15	61±20	47±16	62±21	47±17	63±22	47±18

NOTE — In case of hollow blanks allowances on d_1 are to be taken 50% more than that on d.

TABLE 6 MACHINING ALLOWANCE AND FORGING TOLERANCES FOR FREE-FORGED RING

(where : $h \leqslant d$, $d_1 \geqslant 1/3d$)



All dimensions in millimetres.

OUTSIDE DIAMETER 'd' OF THE FINISHED PRODUCT		HEIGHT 'h' OF THE FINISHED PRODUCT																									
	OVER →	—		63		100		160		200		250		315		400		500		630		800		1 010		1 260	
	UP TO AND INCLUDING →	63		100		160		200		250		315		400		500		630		800		1 010		1 260		1,550	
		ALLOWANCE ON																									
From	To	d, d_1	h	d, d_1	h	d, d_1	h	d, d_1	h	d, d_1	h	d, d_1	h	d, d_1	h	d, d_1	h	d, d_1	h	d, d_1	h	d, d_1	h	d, d_1	h	d, d_1	h
63	100	—	—	8±3	7±2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
101	160	10±3	9±2	11±3	9±2	12±4	10±3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
161	200	11±3	9±2	13±4	10±3	15±5	11±4	16±5	12±4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
201	250	13±5	10±3	15±5	10±3	16±6	12±4	18±6	14±5	20±7	16±6	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
251	315	14±6	10±3	16±6	11±4	18±7	13±5	20±7	15±5	22±8	17±6	22±8	19±7	—	—	—	—	—	—	—	—	—	—	—	—	—	—
316	400	18±6	12±4	20±6	13±4	20±7	15±5	22±7	17±5	24±8	19±6	26±9	21±7	30±10	25±8	—	—	—	—	—	—	—	—	—	—	—	—
401	500	22±7	14±5	24±7	16±5	26±8	20±6	26±8	22±6	28±9	23±7	30±10	25±8	35±10	30±8	40±12	35±10	—	—	—	—	—	—	—	—	—	—
501	630	—	—	28±9	20±6	33±9	26±7	34±10	28±8	35±11	28±9	36±11	30±9	40±12	35±10	43±14	36±12	—	—	—	—	—	—	—	—	—	—
631	800	—	—	34±10	28±9	36±11	30±9	37±11	32±10	39±12	33±10	40±12	34±10	42±13	35±10	44±13	37±11	47±14	40±12	—	—	—	—	—	—	—	—
801	1 000	—	—	36±11	30±9	38±11	32±10	40±12	34±10	42±13	35±11	44±13	37±11	46±14	39±12	48±14	41±12	51±15	43±13	54±16	47±14	—	—	—	—	—	—
1 001	1 250	—	—	44±13	35±11	44±13	37±11	45±14	38±11	47±14	39±12	49±14	41±12	51±15	43±13	53±16	45±13	56±17	47±14	58±17	49±14	61±18	52±15	—	—	—	—
1 251	1 600	—	—	—	—	49±14	41±12	50±15	42±13	51±15	43±13	53±15	46±13	56±17	47±14	59±18	49±14	62±18	52±15	64±19	54±16	67±20	57±17	70±21	61±18	—	—
1 601	2 000	—	—	—	—	—	—	57±17	48±14	58±17	49±14	59±18	50±14	61±18	51±15	64±19	53±16	67±20	56±17	72±22	61±18	76±23	65±19	80±24	68±20	—	—
2 001	2 500	—	—	—	—	—	—	—	—	63±19	52±15	65±19	53±16	67±20	55±16	70±20	58±17	74±22	62±18	78±24	68±20	83±28	73±22	88±26	78±24	—	—
2 501	3 200	—	—	—	—	—	—	—	—	72±22	60±18	73±22	61±18	75±23	62±18	78±24	65±19	81±24	68±20	87±26	76±24	92±28	82±24	99±30	88±26	—	—
3 201	4 000	—	—	—	—	—	—	—	—	—	—	81±24	67±20	83±24	69±20	86±26	72±22	89±27	76±22	95±29	79±24	99±30	85±26	105±32	96±29	—	—
4 001	5 000	—	—	—	—	—	—	—	—	—	—	—	—	92±28	77±24	95±29	80±24	97±29	82±24	100±30	85±26	102±31	91±28	105±32	94±29	109±33	100±30

TABLE 7 ADDITIONAL MACHINING ALLOWANCE FOR FREE-FORGED THIN WALLED RINGS

All dimensions in millimetres.
(Over the Allowance for Ring)

Outside Diameter 'd' of the Finished Product		Wall Thickness of the Product						
		Over →	—	4	6·3	10	16	25
From	To	Up to and Including →	4	6·3	10	16	25	40
			Additional Machining Allowance, Percent					
			When $h \leqslant d, d_1 \geqslant \frac{1}{3} d$					
63	100		40	30	—	—	—	—
101	160		50	30	20	—	—	—
161	200		50	40	30	20	—	—
201	250		50	40	30	20	—	—
251	315		60	50	40	30	20	—
316	400		60	50	40	30	20	—
401	500		70	60	50	40	30	20
501	630		70	60	50	40	30	20

3.2 Eccentricity Allowance — Additional machining allowance has to be provided to take care of the eccentricity between the steps.

3.2.1 In case of shafts where d_1/d_2 or d_2/d_3 or d_1/d_3 (Fig. 2) $\geqslant 1{\cdot}6$ and $0{\cdot}8\, d_1 < l < 8\, d_1$, provision for eccentricity allowance has to be considered in the sections where the condition satisfies.

Eccentricity allowance $= (d_1 - d_2)\ 0{\cdot}05$ or $(d_2 - d_3)\ 0{\cdot}03$

3.2.1.1 In case of multistepped shafts this allowance has to be considered for each step where the above condition satisfies and the maximum of the eccentricity allowance to be provided on sections by the technologist keeping in view the economics of material and process.

3.2.2 In case of shafts where $l > 8\, d_1$ and d_1/d_2 or $d_1/d_3 > 1{\cdot}6$ eccentricity allowance has to be provided as per Fig. 1.

4. SHAPE OF FORGING

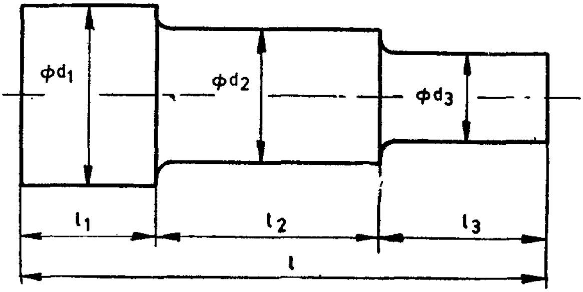
4.1 Stepped Shafts — *See* Fig. 3.

4.1.1 *Minimum Height of Steps*

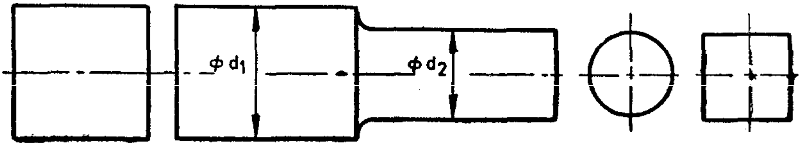
$$H_{\min} = (T_L + T_u) \left(1 - \frac{l_2}{2L} \right) \geqslant 5 \text{ mm for } D_1 < 100, \text{ and}$$
$$\geqslant 10 \text{ mm For } D_1 \geqslant 100$$

where

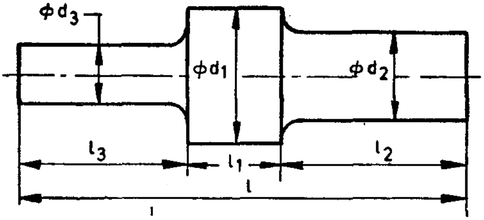
T_L = lower tolerance, and
T_U = upper tolerance.



2A Stepped Shaft



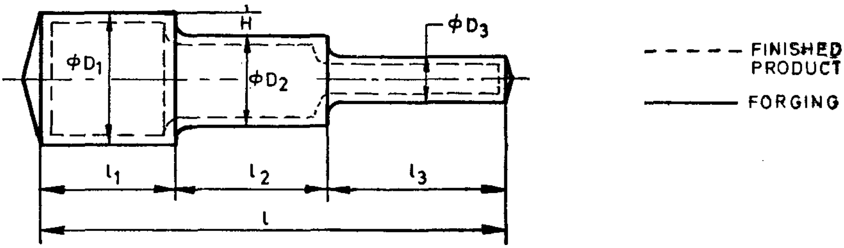
2B Flanged Shaft



2C Necked Shaft

NOTE – Dimensions indicate machined size only.

FIG. 2 FIXING OF FORGING ALLOWANCES AND TOLERANCES ACCORDING TO THE SHAPE OF FORGINGS



NOTE – After providing allowances and tolerances as per **3.1** and **3.2**, the above forging sketch is prepared.

FIG. 3 STEPPED SHAFT

4.1.2 *Maximum Range of Steps*

$$\frac{D_1}{D_2} \leqslant 2{\cdot}5; \quad \frac{D_2}{D_3} \leqslant 2{\cdot}5; \quad \frac{D_1}{D_3} \leqslant 4$$

In case the ratio of steps is more than the permissible maximum ratio, suitable technological allowance has to be provided to bring the ratio within limit.

4.1.3 *Minimum Length of End Step*

$$l_{3\min} = 0{\cdot}4 \frac{D_2^3}{D_3^2} \geqslant 0{\cdot}1 l \geqslant \frac{1}{2} \text{ width of pallet}$$

4.1.4 *Minimum Distance Between Steps*

a) $l_{2\min} = 1{\cdot}2 \frac{(D_1 - D_2)}{3} \geqslant 50 \geqslant \frac{l_3}{2}$

b) $l_2 D_2^2 + l_3 D_3^2 \geqslant 0{\cdot}4 D_1^3$

4.2 Flanged Shaft (*see* Fig. 4)

where a) $\frac{D_E}{D_1}$ or $\frac{D_M}{D_1} \geqslant 1{\cdot}5$ but $\leqslant 2{\cdot}5$, and

b) $L_E < 0{\cdot}5 D_E$ or $L_M < 0{\cdot}5\, D_M$

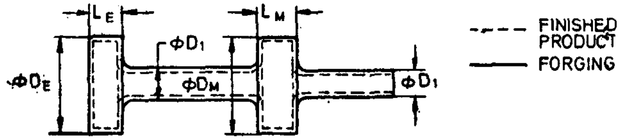


FIG. 4 FLANGED SHAFT

4.2.1 *Minimum Width of End Flange*

$$L_{E\min} = \frac{D_E - D_1}{2} + 0{\cdot}07 D_E \geqslant 70 \text{ mm}$$

4.2.2 *Minimum Width of Middle Flange*

$$L_{M\min} = \left[\frac{D_M - D_1}{2} + 0{\cdot}07 D_M \right] 0{\cdot}7 \geqslant 70 \text{ mm}$$

4.3 Necked Shaft (*see* Fig. 5)

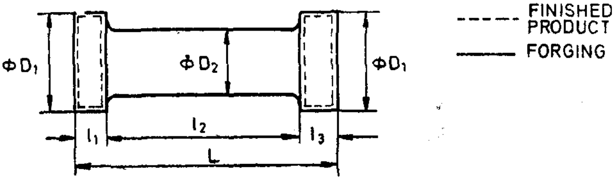


FIG. 5 NECKED SHAFT

$$D_{2\text{min}} = D_1 \sqrt{\frac{W_P}{l_2}}$$

where

W_P = width of pallet, and

D_1 = smaller of the end diameters of the neck in case the flange diameters are not equal.

In case $D_2 < D_{2\text{min}}$, technological allowance has to be provided.

(*Continued from Page* 2)

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